ISSUE 2 / 2012

DATA – FACTS – ANALYSIS

CUTEC-News

BIOGAS TO ELECTRICITY

SAVE THE DATE

I recently received an e-mail with the unusual heading “Save the Date”. The message contained an invitation to attend a company’s 25th anniversary event in the summer. It actually was not a full invitation, as the text merely included some details about the upcoming festivities. Further information was announced for the near future. Apparently the only thing that had been firmly decided was the date which I was asked to mark off in my calendar so that I could be there on the day. A brief hunt for this expression using a popular search engine returned more than a million hits. I now realise that this way of announcing the date of an upcoming event has become very popular in the English-speaking world, not just for anniversary events as mentioned above. It is also used for wedding announcements. When I now ask CUTEC readers to “save the date”, you will be right in assuming that I am not sending out a wedding announcement. Instead, I would like to draw your attention to two events. On June 5th and 6th, we will be putting in a guest appearance at Environment Week at the invitation of the President of Germany and the German Environment Foundation (DBU) in the park at Bellevue Palace. We will be sharing information there on our joint Zinc Recovery from Steel Scrap Project. Also in June, we will have our own stand at ACHEMA in Frankfurt. Our emphasis at the show will be on material and energy resource efficiency. So please save the dates (in other words mark them down now in your diaries). You are cordially invited to visit us at both venues.

There is no need to wait if you want to find out more about the work that is currently in progress. The latest issue of CUTEC News, which you are now holding in your hands, tells you more about a very diverse range of material and energy efficiency projects.

Yours sincerely, Otto Carlowitz

CNM MAKES AN ACTIVE CONTRIBUTION TO HIGH-TECH METAL RECYCLING TECHNOLOGY

The REWIMET association (Lower Saxony strategic industrial metals recycling cluster) emerged at the beginning of 2011 from a joint initiative which had been launched by companies and research organisations at the regional level. More information is available at http://www.rewimet.de/. The initiative was driven by market shortages of high-tech metals such as gallium, germanium and indium. Lower Saxony Economics Minister Bode attended the association’s founding event. Dr. Westphal and Prof. Goldmann are the association Chairmen. CUTEC is one of the founding members. The Sustainability Management Cluster* (CNM) including Dr. Kragert, Dr. Zeller and Mr. Sauter represent CUTEC and are actively involved in the ongoing development process.

The association’s goal is to bring together the scientific and business communities in a joint research effort to develop a roadmap for ensuring the long-term availability of strategic industrial raw materials. Besides developing innovative recycling techniques to exploit secondary sources of strategic raw materials, the partners are concentrating on continued development of primary processing to get the most out of the raw materials. This includes a reduction in CO_2 emissions and material stream management strategies to optimise raw material utilisation.

There is nothing comparable nationwide to this unique concentration of recycling companies in the Vorharz greater municipal region. This unique partnership which includes TU Clausthal and CUTEC is the only one of its kind in Germany in the field of strategic industrial metal recycling.

The government of Lower Saxony, particularly the Ministry of Economics, Labour and Transport and the Ministry of Science and Culture, supports this initiative.

Continued on page 3

NEW PROJECT INVESTIGATES RESOURCE-EFFICIENT OFF-GAS PURIFICATION FOR MBT

Fig. 1: Pilot system in a sample industrial application

For several years now as part of its work on advisory reports and publications, the Stationary Flue Gas Purification Group at CUTEC has been looking into operational problems associated with RTO (Regenerative Thermal Oxidation) in the mechanical-biological treatment (MBT) of municipal waste. In collaboration with the MBT plant operators association (ASA) and the engineering firm iba in Hannover which has provided support at many MBT plants, a research project has been acquired to investigate the optimization of MBT off-gas purification. The project entitled "Holistic Development of Resource-Efficient Operational Techniques for RTO-based MBT" is being funded by the German Federation of Industrial Research Association under the umbrella of the Federal Ministry of Economics and Technology's SME Innovation programme.

Following installation of RTO (Regenerative Thermal Oxidation) off-gas purification systems nearly simultaneously at roughly 50 MBT facilities, three problem areas have been identified:

- Corrosion, particularly in the raw gas inlet and purified gas outlet systems caused by the inflow and oxidation of acidifiers
- Deposits and material adhesion in the thermal storage block caused by the oxidation of organosilicon compounds and inflow of ammonium salts
- Unexpectedly high incremental fuel consumption attributed to sub-optimal process conditions

As first-generation RTO systems are scheduled for replacement in the near future, the goal of the project partners is to create an engineering basis for optimising the MBT process including RTO off-gas purification. The project has been subdivided to address three areas:

- Work Package A (iba): Reduce the corrosion potential in the RTO process, increase the organic off-gas content and reduce siloxane levels in the exhaust air by targeted decomposition optimisation or off-gas pre-treatment
- Work Package B (CUTEC): Reduce the corrosion potential in the RTO system through additional pre-heating of the exhaust air, conduct trials on a new approach to RTO design in order to simplify the handling of deposits, assess and validate different methods for reducing incremental fuel consumption
- Work Package C (iba and CUTEC): Improvement of conventional RTOs so that improved conventional RTO systems are available from different manufacturers

The engineering and planning services developed during the course of the project can be utilised at more than 50 companies (most of which have RTO lines), making a valuable contribution to a more targeted use of the investments which will be needed.

CUTEC will be mainly focusing on the deployment of new RTO technology developed in collaboration with the Bayreuth-based firm LTB. The single-tower system featuring a ceramic ball bed significantly reduces the problems associated with deposits and material adhesion. The pilot system (Fig. 1) already has a proven track record in various industrial applications. The design is now being enhanced, so that the system will be able to handle the more demanding operating conditions at MBT facilities. In addition, to provide corrosion protection the new system will be combined with an acidic washer (to remove the ammonium compounds) and a tubular heat exchanger to raise the exhaust air temperature. It will then be possible to run large parametric studies to assess all 3 problem areas (Fig. 2). (ne)

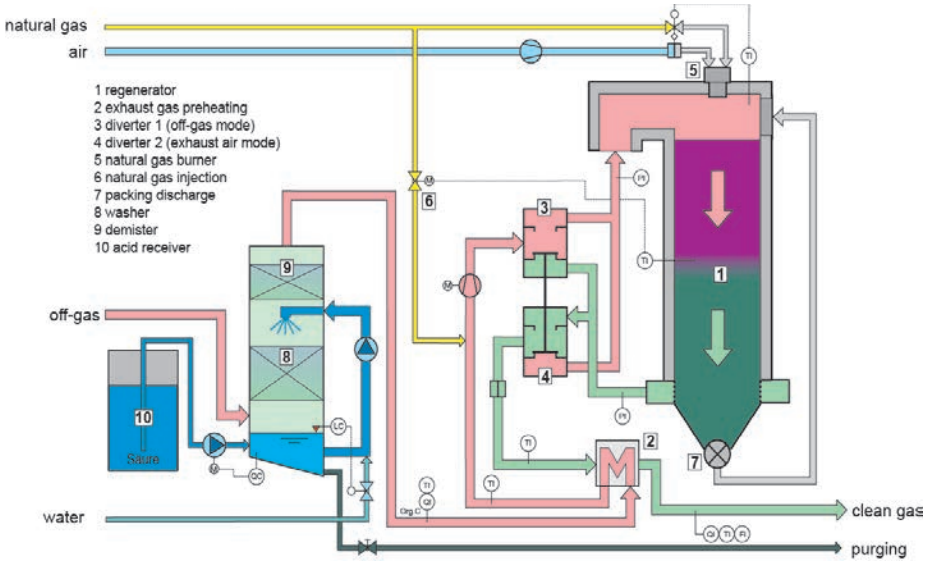


Fig. 2: Process diagram showing the test setup

MODEL-BASED PROCESS CONTROL FOR ENHANCED BIOGAS PRODUCTION EFFICIENCY

Substantial enhancements are needed to make biogas plants more efficient. The objective should be to produce more biogas from a lower volume of raw materials, with less agricultural land being set aside to grow the input material. In addition to successful biomass breeding programmes and improved gas production and upgrading techniques, process control optimisation can also help enhance the efficiency of biogas production.

A project conducted in collaboration with project partner Common-Link AG, Karlsruhe and funded by the German Federal Ministry of Economics and Technology (BMWi) via AiF Projekt GmbH was launched to calibrate a dynamic process model for anaerobic substrate conversion. The approach taken on this project is intended to resolve difficulties associated with aligning process models with real world conditions. The problems are generally attributed to the fact that the many biochemical reaction parameters and the various quantities of microorganism groups involved are unknown or not sufficiently understood. Anyone who has ever worked with dynamic process models knows how difficult it is to align a digestion model, which is targeted specifically at microorganisms, with the real world. Even then, you can never be sure that the model accurately reflects dynamic behaviour.

An experimental model calibrator, which determines the kinetics and effectivity of different groups of microorganisms, can be useful to help address the difficulties. The model calibrator will be used to regularly verify the effectivity of the bio sludge on an ongoing basis. By calibrating the model, we will be able to estimate the future digestion characteristics of different substrate mixtures and volumes. At a mean residence time of around 30 – 50 days in biogas plants, a forecast covering a period of at least 2 - 3 weeks should be feasible.

Fig. 1: Gas detector at the CUTEC bio lab

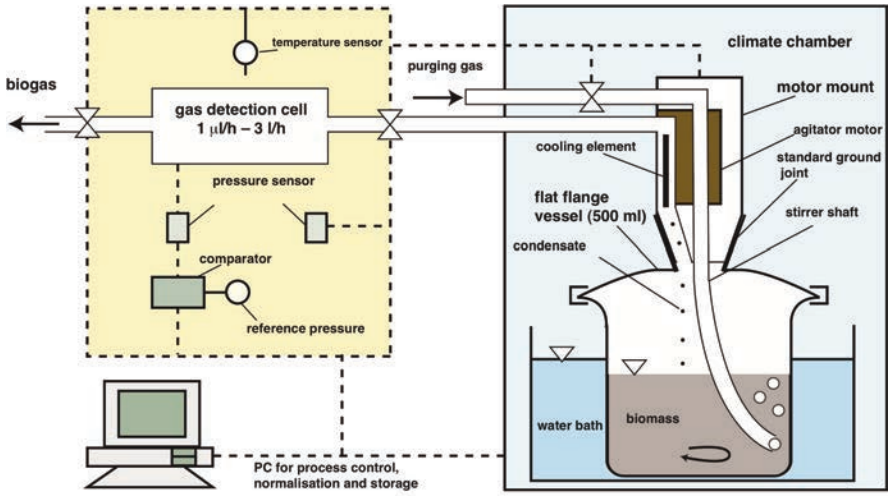


Fig. 2: Schematic diagram of the gas detector

It is our expectation that the model-based process analysis will provide important additional information which will help plant operators e.g. with the planning of substrate logistics management, load/reserve capacity and dynamic operation near the maximum efficiency point. Further enhancements will support functionality such as the analysis of growth characteristics for specific microorganisms under varying nutrition and process conditions.

Basis of the model calibrator is a gas detection cell developed in-house (see Fig. 1). This is because a reproducible and highly accurate detection of gas volumes at resolutions in the µL/h range is essential in order to define "model parameters" which produce good enough results (the procedure is illustrated in Fig. 2). Users who may be interested are invited to contact us. We would also be willing to discuss follow-on project partnerships. (si)

Continuation from page 1

CNM makes an active contribution to high-tech metal recycling technology

That is clear from the recommendations made by the state government's 6th Resource and Energy Efficiency Commission, which include placing the recycling cluster which is focusing on an improvement in the supply of raw materials from secondary sources on the agenda in discussions with the Federal Environment Ministry and the EU.

The German resource efficiency programme (ProgRess) which was given the green light by the German Cabinet on February 29th, 2012 takes account of this recycling initiative. Further information is available online at: http://www.bmu.de/wirtschaft_und_umwelt/ ressourceneffizienz/ ressourceneffizienzprogramm/doc/47841.php.

It is the first project which was launched in the context of the Harz Future Initiative (IZH) sponsored by the Lower Saxony Ministry of Economics. Under the umbrella of the EFRE programme, the N Bank approved an application for funding to develop the REWIMET organisation. Dr. Kragert will provide part-time scientific administrative support funded by the project. CNM played an instrumental role in putting together an application for submission to the Federal Ministry of Education and Research for a REWIMET research camp in Clausthal. Besides CUTEC, seven university departments at TU Clausthal, one department at the University of Magdeburg, ten leading companies in the region and two counties were involved in submission of the application for the research camp. (ze/sr)

BIOGAS TO ELECTRICITY USING SOFCS

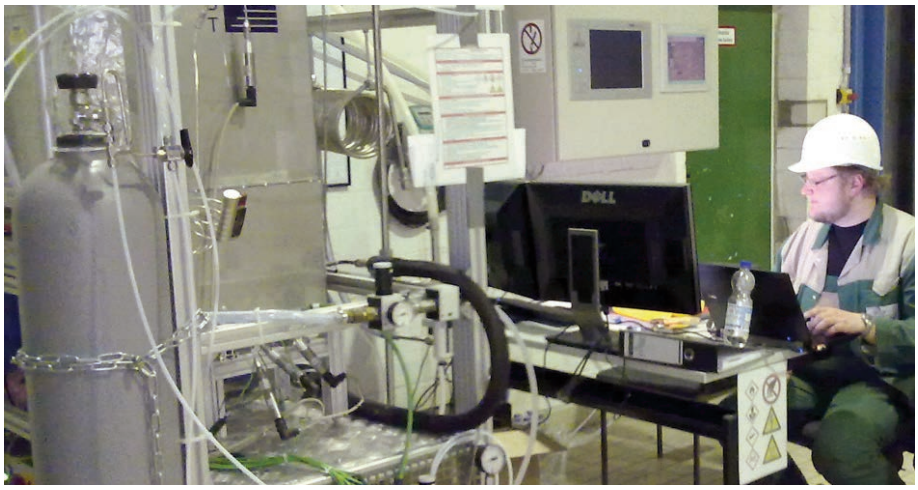
From lab-scale system to biogas plant at a sugar factory

Biogas is a rapidly expanding source of renewable energy in Germany. The gas is produced from organic agricultural or food residue or municipal bio waste. Most of the biogas is used at gas engine CHP plants to generate electricity, with efficiencies ranging between 25 % and 40 %. Strategies to make use of the process heat are needed to fulfil the requirements which must be met to obtain funding from the EU.

In the output range below 100 kW, improving the efficiency of electricity generation from biogas is desirable, especially as the investment and operating costs increase disproportionally as electrical output decreases. A greater proportion of heat is also generated, making it even more difficult to find a meaningful use for the heat at the site.

By directly converting the chemical energy stored in the biogas to electricity, the high-temperature fuel cell (SOFC, Solid Oxide Fuel Cell) can increase efficiency to the levels needed. Under the umbrella of an Industrial Research Partnership project funded by the Federal Ministry of Economics and Technology, CUTEC is working alongside of ZBT to develop an SOFC-based process which will enable operators of small biogas plants to produce electricity without having to find ways of utilising large amounts of low-calorific waste heat.

Complete SOFC system for highly efficient generation of electricity from biogas



Member of the CUTEC team operating the SOFC system at the Nordzucker biogas system in Uelzen

The process initially uses a reforming process to convert the methane contained in the biogas along with the CO_2 which is produced during biomass digestion into a hydrogen-rich gas. The reformate gas is then efficiently converted into electricity in the SOFC fuel cell at around 850°C.

The system used to demonstrate the basic feasibility and the efficiency advantage is based on a 1 kW SOFC fuel cell module provided by the Dresden-based firm Staxera.

The system was designed, built and characterised at the CUTEC Test Centre over the course of the three-year project. Using modified biogas as the fuel, electrical output exceeded 900 W and electrical efficiency was as high as 52%. This is significantly better compared to the performance of competing technologies.

In December 2011 following the conclusion of the trials at the CUTEC Test Centre, the system was installed in the biogas plant at the Nordzucker site in Uelzen, where it could be tested under realistic conditions. Besides finding out what output and efficiency levels are achievable in actual operation, the researchers were particularly interested in analysing the system's dynamic characteristics, as the composition of the biogas fluctuates due to process-related factors. The system is regulated to ensure that the fluctuating composition of the biogas remains under control and does not have a negative impact on system performance. During the field test phase, the expected advantages were demonstrated under actual operating conditions.

The tests also revealed that overall system performance degraded over time. CUTEC with the support of its project partner and the industrial partners involved is currently investigating the specific reasons for the fall-off in performance. Another extended test of the complete system is scheduled to take place once the investigations are complete.

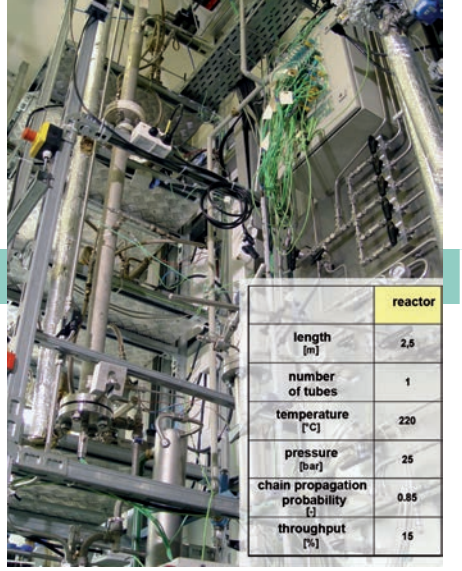
Well-known industrial partners in the fuel cell and biogas systems industry will provide support to the researchers. The project partners would especially like to thank Staxera and Nordzucker. The contribution and commitment shown by the two companies ensured that the project could be completed on schedule.

In order to demonstrate the advantages of SOFC technology for generating electricity from biogas on a scale that would be relevant to users, the researchers are currently looking for partners in the biogas industry who might like to get involved in the development and marketing effort for this innovative new process. Please contact us if you are interested.

We invite you to have a discussion with us on the technique we are using, the results we have achieved and the challenges that remain. Visit us at Hannover Messe 2012 and take a first-hand look at our SOFC system which will be on display at the joint "Energy from Lower Saxony" stand. We look forward to a stimulating conversation. See you there. (li)

COMPLETION OF FISCHER-TROPSCH PILOT SYSTEM

Moving up from pints to barrels



	reactor
length [m]	2.5
number of tubes	1
temperature [°C]	220
pressure [bar]	25
chain propagation probability [-]	0.85
throughput [%]	15

Fig. 1: Starting point for the design of the pilot system: the lab-scale FTS which was studied in detail

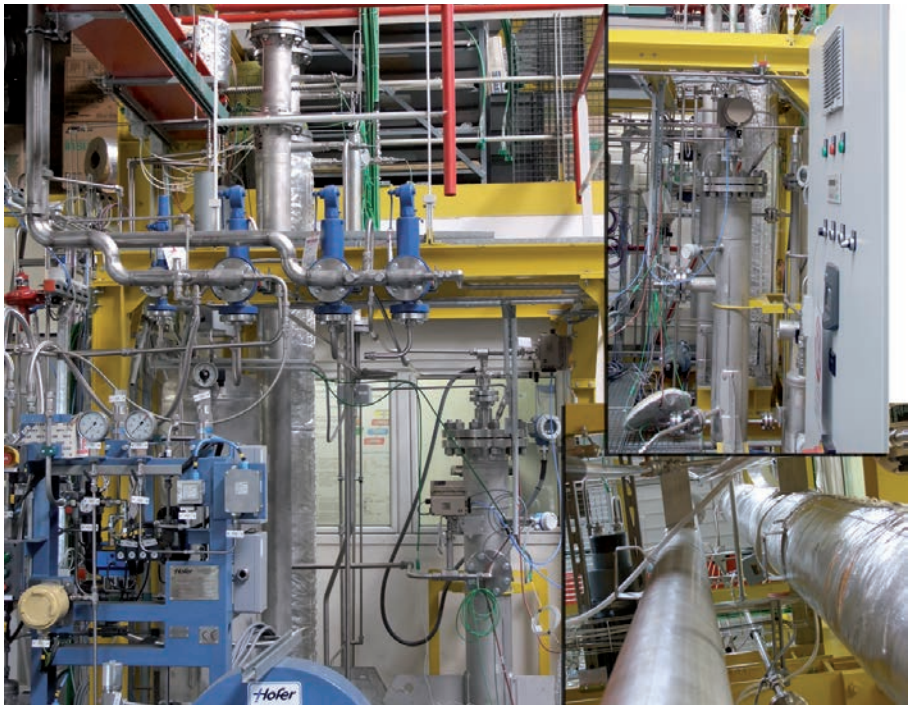


Fig. 3: Photos of the FTS pilot system

In November 2009, the Lower Saxony Ministry of Science and Culture gave the go-ahead for a project to design and build a pilot-scale Fischer-Tropsch Synthesis (FTS) system. The goal of the project was to add FTS to the existing thermochemical biomass conversion systems so that the entire process chain from the biomass to the F-T fuel end product can be implemented on a pilot scale.

The syngas needed for F-T production of fuel from biomass is supplied by a circulating fluidised bed gasifier which is installed at CUTEC and has a syngas output capacity of roughly 200 – 300 Nm3/h. At the time when the application was submitted, the existing gas purification equipment and pilot FTS system (Fig. 1) were only able to upgrade a fraction of the gas produced and process them into F-T products. Only about 1 litre (2 pints) of diesel could be produced per week when trials were conducted in three-shift operation. That amount is sufficient for chemical analysis but not for larger-scale trials, e.g. for running test-bed engines on F-T fuel.

When the Thermal Process Technology team completed work on the ABSART gas upgrading system in mid-2011, there was then a need to expand the capacity of the synthesis system as well to make all of the steps in the process available in pilot systems which can be upscaled. The two primary considerations during the design of the FTS pilot system were as follows:

1. The system had to have sufficient capacity to handle around 25 Nm3/h of syngas supplied by the ABSART upgrading system.
2. The yield of the F-T system had to be increased to the point where about one barrel (approx. 160 litres) of F-T diesel could be produced with reasonable effort (i.e. within roughly two weeks) for use in test bed trials.

Based on this requirements profile, a system was designed which consists of two tubular reactors (each 6 m in length) connected in series. The two-stage design makes it possible to operate the reactors at different temperature and pressure levels. As a result, the system can

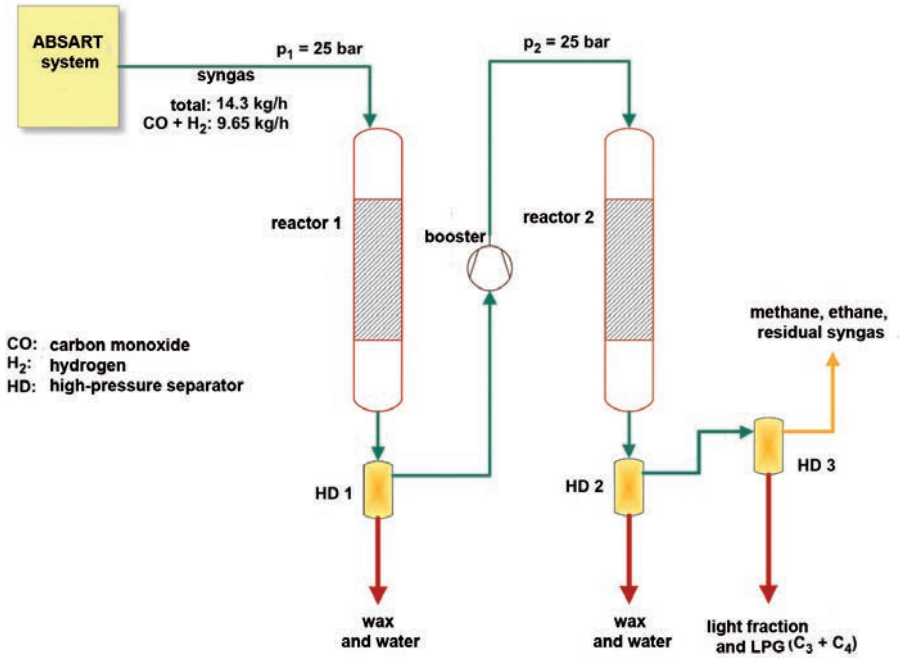
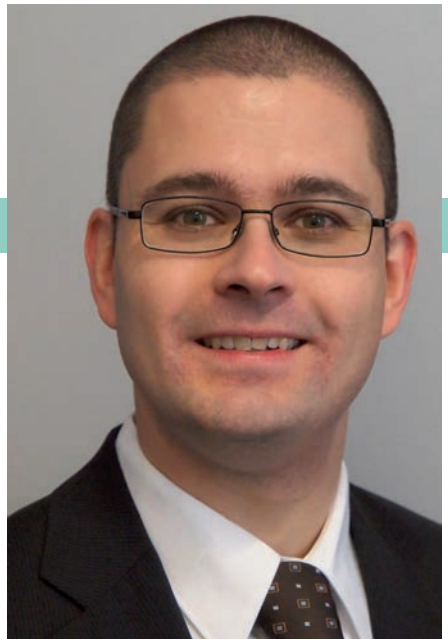


Fig. 2: Diagram and technical details of the new FTS pilot system

Continued on page 6



Prof. Christian Bohn

SCIENTIFIC ADVISORY BOARD

A profile of Prof. Christian Bohn

Christian Bohn was born in Hamburg in 1969. After finishing his Abitur (A levels), he went on to obtain a degree in Electrical Engineering in Braunschweig in 1994. During his degree course, he spent a year at the University of Sussex in Brighton on an Erasmus scholarship, where he met his future wife who is from America. After receiving his degree, he moved on to Ruhr University in Bochum where he worked as a research assistant and doctoral candidate in the Electrical Control Engineering Department. During his doctoral programme, he was awarded a grant to conduct research at the University of Ulm in 1996 before obtaining his doctorate with distinction in 2000. The topic of his dissertation was state and parameter estimation on non-linear systems. That same year, Dr. Bohn joined Continental in Hannover where he began working as a design engineer for automotive electrical systems before taking up a post as Project Manager. Four years later, he accepted an offer from the automotive supplier IAV. At his new company, he developed control algorithms and calibration techniques, and he also worked in engine controller applications engineering. He was later appointed Team Leader, taking charge of development for components used in series production of hybrid vehicles. In 2007, Dr. Bohn received offers from three German universities within a short space of time, and he decided in favour of TU Clausthal. He was appointed Professor (W3) of Control Engineering and Mechatronics at the university's Electrical and Computer Engineering Institute (IEI). He commutes between Clausthal and Hannover where he lives with his family. His research activities are concentrated on mechatronics system modelling, identification and control as well as mining and automotive control engineering applications. Another area of specialisation is active vibration control, something which Professor Bohn has been working on for more than 10 years. He joined the CUTEC Scientific Advisory Board last year at the request of the Chairman, Professor Wesling. When asked about what he would like to contribute to the board, Professor Bohn said the following: "With my background in Control Systems Engineering, I would like to contribute my expertise in modelling, system identification and control systems and also act in an integrative and abstracting capacity on the CUTEC Scientific Advisory Board. That would seem to be a meaningful extension of the CUTEC knowledge base, particularly in the field of modelling and simulation. I have no doubt that both disciplines, namely environmental engineering and control engineering, will benefit. A first concrete step in this partnership will be a project during which a doctoral candidate at both institutions (IEI and CUTEC) will work on modelling and control of waste water treatment under the direction of Professor Sievers (CUTEC) and me. (he)

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Completion of Fischer-Tropsch pilot system

produce sufficient quantities of F-T products while at the same time offering the flexibility to conduct scientific studies on a pre-commercial system. No other system of comparable size and flexibility is available anywhere in Europe. It is yet another factor which sets CUTEC apart and enhances our standing in the field of thermochemical biomass conversion on the national and international stage.
Fig. 2 shows the technical details.

The system is now complete. Cold commissioning is underway to check for leaks, test the control system and make minor modifications. The system is planned to go "live" at the end of 2012. We have already received queries regarding production of large quantities of F-T fuel. We hope to acquire some projects in the near future which will enable us to keep the system operating. Articles will appear in future issues of CUTEC News to keep you up to date as events unfold. You are welcome to take a first-hand look at the system in operation and discuss technical or business details. Feel free to contact us. (wo)